

Interactive comment on “Evaluation of North Eurasian snow-off dates in the ECHAM5.4 atmospheric GCM” by P. Räisänen et al.

Anonymous Referee #2

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General Comments

This paper utilizes in situ snow course measurements and satellite passive microwave estimates of snow off date to evaluate the ECHAM4.5 atmospheric GCM. Because neither the in situ measurements, satellite data, nor model simulations provide direct values of snow off date, clear explanations and justifications are provided for the derivation of snow off date from these three sources. A set of historical ECHAM4.5 sensitivity simulations were utilized to show the model response to nudged parameters related to atmospheric circulation, and changes to the parameterization of surface albedo in the model. In situ measurements from Sodankyla, Finland provide convincing evidence that early snow melt in the simulations, despite a cold temperature bias, are due to the failure to calculate the energy budget separately over snow-covered and snow-free

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fractions of the grid cell. Explanation for the regions with a late snow melt bias are somewhat less convincing, but the attribution to the lack of vegetation canopy shading in the model seems sound.

I have a number of suggestions that will hopefully improve the final version of the manuscript:

1. The introduction provides clear information on the background and context for this study, but some fundamental citations on simulated versus observed snow albedo feedbacks are missing. I suggest consideration of the following:

Qu, X., and A. Hall. 2007. What controls the strength of snow-albedo feedback? *Journal of Climate*. 20: 3971-3981. DOI: 10.1175/JCLI4186.1

Qu, X., and A. Hall. 2014. On the persistent spread in snow-albedo feedback. *Climate Dynamics*. 42:69–81. DOI 10.1007/s00382-013-1774-0.

Fletcher, C., H. Zhao, P. Kushner, and R. Fernandes. 2012. Using models and satellite observations to evaluate the strength of snow albedo feedback. *Journal of Geophysical Research*. VOL. 117, D11117, doi:10.1029/2012JD017724.

2. Page 3676 lines 26-27: “The ECHAM5 snow scheme considers both SWE intercepted by the canopy and SWE on the ground, the latter being more interesting for this study.” Recent work with the Community Land Model has shown the importance of snow-canopy processes as a source of simulation error in snow albedo (<http://onlinelibrary.wiley.com/doi/10.1002/2014JD021858/abstract>). While the importance of these processes are certainly model dependent, the role of snow-vegetation interactions can be significant.

3. Page 3678 line 6: what is the depth threshold for determining 100% snow cover in the model?

4. 1978-2006 covers the CMIP5 historical simulation time period. Rapid reductions in spring SCE, including northern Eurasia, has occurred between 2007- and 2012, as

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described in:

Derksen, C., and R. Brown. 2012. Spring snow cover extent reductions in the 2008-2012 period exceeding climate model projections. *Geophysical Research Letters*. 39: L19504 doi:10.1029/2012GL053387

Are there any implications on the results of this study related to the 1979-2006 time period? Most CMIP5 models do not capture the observed spring snow reductions over the past 7 years, but the radiometer derived snow off dataset would allow evaluation of model performance during this recent period of rapid change. It is not necessary to add these years to the current paper, but some statements on this issue could be added to the Discussion.

5. This study utilizes a small number of model runs, 3 or 1 depending on the experiment. Was internal model variability with respect to snow parameters quantified at all? A small standard deviation in the 28 year mean snow off date from 3 model runs is used to justify the small number of members. But how does the model variability compare to the observed variability in snow off date? I suggest a panel be added to Figure 2 which shows the standard deviation in satellite derived snow off date as is provided in Figure 2d for the reference simulations.

6. Page 3681 lines 5-11: I was confused by the terminology in this paragraph with respect to 'snow melt date' and 'snow off date'. 'Snow melt' is the onset of wet snow, which the radiometer measurements are very sensitive to. 'Snow off' date is the time when the land surface is free of snow, and occurs at some time lag after snow melt onset. The snow course data can be used to evaluate both of these terms in the radiometer dataset through the use of the snow status flag (for melt onset) or snow depth (snow off when snow depth = zero). It's not clear in this paragraph how the microwave snow off estimates were calibrated. It seems snow melt information was used for calibration but the microwave dataset also provides the snow off date. It's important to clarify this description since the in situ measurements, satellite data, and

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model simulations each provide indirect values of snow off date.

7. The potential differences in how the satellite radiometer and snow course datasets characterize 'snow off' is a source of uncertainty in the model evaluation. I suggest a plot be added which shows a comparison between the microwave and snow course derived snow off dates (i.e. as a scatter plot) for those grid cells where both datasets are available.

8. Figure 5 shows the differences in simulated versus satellite retrieved surface albedo. Is it possible to determine if these differences are driven by snow cover fraction biases or albedo parameterization uncertainties? I suggest adding panels to Figure 5 which show spatial patterns of snow extent or snow fraction bias in the model compared to an observational baseline.

9. Given the potentially important role of forest cover in this study, it would be helpful to provide an observationally derived forest classification and a dominant plant functional type map for ECHAM4.5 as extra panels in Figure 2.

Editorial Changes

The term 'fields' is used throughout the paper to refer to non-forested areas. I suggest changing this to 'open' which better captures non-forested regions both above (i.e. tundra) and below the treeline.

Page 3687 line 14: change 'snow-off to occur' to 'snow-off occur'

Page 3689 line 11: change to 'The changes in snow-off timing...'

Page 3690 line 23: change 'represented' to 'presented'

Interactive comment on Geosci. Model Dev. Discuss., 7, 3671, 2014.

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